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Economics research and climate change. A Scopus-based bibliometric investigation

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*Economics research and climate change. A Scopus-based
bibliometric investigation*

by

Giuseppe Lucio Gaeta, Stefano Ghinoi, Matteo Masotti, Francesco Silvestri

03/2021

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By Giuseppe Lucio Gaeta, Stefano Ghinoi, Matteo Masotti, Francesco Silvestri

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Economics research and climate change. A Scopus-based bibliometric investigation

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Abstract: This paper investigates the evolution over time of the economics literature devoted to climate change. The analysis is based on 1974-2021 data extracted from the Scopus database and focuses on the publication outlets included in the first quartile of the “Economics, Econometric, and Finance” SCImago Ranking. We inspect the size and the impact of this economics literature, the geographical pattern of its production, and we provide a content analysis based on the keywords associated with the documents analysed. This study provides a detailed overview of the (still limited) interest that economists demonstrate for climate change.

Keywords: climate change, economic research, bibliometric analysis

Jel Codes: Q50, Q54

1. Introduction

Scholars unanimously agree that anthropic activity has caused dramatic climate change (e.g. Powell, 2017; Trenberth et al., 2015). Recent estimates suggest that the global average temperature has approximately risen 0.8 to 1.2 °C since the pre-industrial period (IPCC, 2018), and it might significantly grow further over the next decades (Collins et al., 2013). Such warming puts life on earth at risk (IPCC 2018), making climate change one of the most urgent and significant problems that humanity must face (Stern, 2006).

In line with such a perspective, scholarly attention on climate issues has grown remarkably over recent decades, as scientometric studies suggest. Li et al., (2011) demonstrate that climate change-related articles indexed in the Science Citation Index Expanded (SCI-expanded) by the Institute of Scientific Information (ISI) Web of Science (WoS) database moved from 1 in 1907 to more than 800 in 2009, with a notable growth, especially from the 1990s. Stanhill (2001) shows that the annual number of climate change-related publications' abstracts appearing in the American Meteorological Society journal has doubled every 11 years over the 1951-1997 time span. According to (Haunschild et al. (2016), from 1980 to 2014 the number of WoS-indexed scientific papers on climate change has increased even more rapidly, doubling every 5-6 years. Further studies demonstrated the growth of climate change-related scientific production has been particularly impressive in Arab countries (Zyoud and Fuchs-Hanusch, 2020) in Latin American and Asian ones (Saravanan et al., 2014).

Multiple academic disciplines contributed to this growing body of scientific literature. Each one provides its perspective on the climate change features, its causes and consequences, and how people cope with this problem. According to recent scientometric analyses, in the last fifteen years, the social sciences display the most substantial increase in the number of published scientific articles devoted to climate change (Haunschild et al., 2016). This evidence is comforting, giving the valuable contribution that these sciences might provide to facing climate issues (Victor, 2015).

In this framework, economics is deemed to play an important role (Toman, 2006). Economics studies allow to understanding how to trigger the technological change that helps in reducing social and economic activities' environmental impact (Jaffe et al., 2003), how to estimate the economic impact of climate change (Tol, 2009), examine costs and benefits arising from climate policy choices (Stern, 2006), inspect the institutional features and the political will that activate climate policy decisions (Facchini et al., 2017; Lachapelle and Paterson, 2013), and examine the behavioural responses to climate changes and climate policy (Pollitt and Shaorshadze, 2013).

In line with this perspective, it is not surprising that climate change has been recognized as an essential field of economics research, like others such as economic growth theory and general-equilibrium theory (Nordhaus, 2019). This is confirmed by the award of the 2018 Nobel Prize in Economic Sciences to William Nordhaus, for his outstanding research on climate change. Despite such a recognition of the importance and quality of the economists' research on this topic, scholars recently pointed out that the number of economic studies devoted to climate change is surprisingly scarce.

Goodall (2008) highlights that between 1970 and 2006, the top thirty ISI-indexed economics journals published only 63 articles on climate change or global warming. This finding is consistent with those by Goodall and Oswald (2019), who notice that from 2000 to 2019 only 11 articles out of the 47,000 published in the 50 journals included in the Financial Times Research ranking of business schools (FT50) are devoted to biodiversity and species decline, an issue intimately related to climate change (McCarthy, 2001). In the same vein, Oswald and Stern (2019) report that the nine universally considered major "general" economics journals have published only 57 papers - out of approximately

77,000 - linked to climate change (Roos and Hoffart, 2021) provides additional evidence showing that only 1.81% of the papers published in the top five WoS-indexed economics journals over 1957-2019 include the word “climate change” in the document’s title.

Overall, these figures clash with the idea that climate change is one of the most significant scientific, economic, and policy issues of our era (Oswald and Stern 2019) and suggest that economists are not yet adequately tackling the climate change issue. (Roos and Hoffart, 2021) reveals that this picture changes once the analysis shifts from the top five economic journals to the entire set of WoS-indexed economics journals. Indeed, between 1957 and 2019, the economics journals published approximately 1,300 papers that include “climate change” in the document’s title and about 5,500 papers that concern the climate-change topic. According to these numbers, economics papers represent approximately 12% of the WoS-indexed climate change-related research published by all study fields. According to this evidence, climate change is not a central topic for the top five economics journals, while it has found some space among less renowned ones.

The present paper aims to extend the bibliometric evidence on the economic research concern for climate change. Three main features distinguish our work from previous literature and qualify our contribution. First and foremost, differently from the existing papers, which are mainly based on WoS data, our work focuses on the Scopus database. Like WoS, Scopus has a strict selection policy for the inclusion of research content; however, it includes a larger number of publication outlets (Martín-Martín et al., 2018), which is particularly valuable for our analysis since it aims to take into account a broad set of research. Second, our study focuses on the leading Scopus-indexed economics publication outlets, that we identify by looking at the economics field Quartile 1 (Q1) class proposed by Scopus relying on the SCImago Journal Rank (SJR) size-independent prestige indicator of publications (Guerrero-Bote and Moya-Anegón, 2012) and by selecting those outlets that were included in this class at least five years over the last twenty. This allows us to focus our attention on many publication titles (n=190) representing the leading economics publication outlets globally. Third, we complement such an analysis of the current size and the evolution over time of the economics literature with an extensive examination of the citations received by the selected literature, a study of the geographical pattern of the existing publications and of cross-country collaboration networks, an analysis of the research content of the publications.

The bulk of the paper is organized as follows. Section 2 illustrates how we collected our data on climate-change research by querying the Scopus database; it also describes the statistical elaborations to inspect them. Section 3 provides a detailed presentation and discussion of our results. Finally, section 4 illustrates conclusive remarks.

2. Data and methods

Once clarified the topic under investigation, the first step in a bibliometric analysis consists in defining the search strategy (Linnenluecke et al., 2020). In this stage, the database used for the search and the documents’ inclusion and exclusion criteria are highly relevant.

The choice of the database is not neutral (Aria and Cuccurullo, 2017). Our analysis relies on the Scopus database because of the following reasons. First, Scopus is considered the largest repository of peer-reviewed scientific documents and the primary source for scientific citation data together with WoS, which, however, has a low coverage of publication outlets¹ in Social Sciences (Mongeon and

¹ From here onwards we will use the term “titles” to identify the publication outlets. We are consciously using this term instead of “journals” because it has a broader meaning, including also reviews, handbooks, and others.

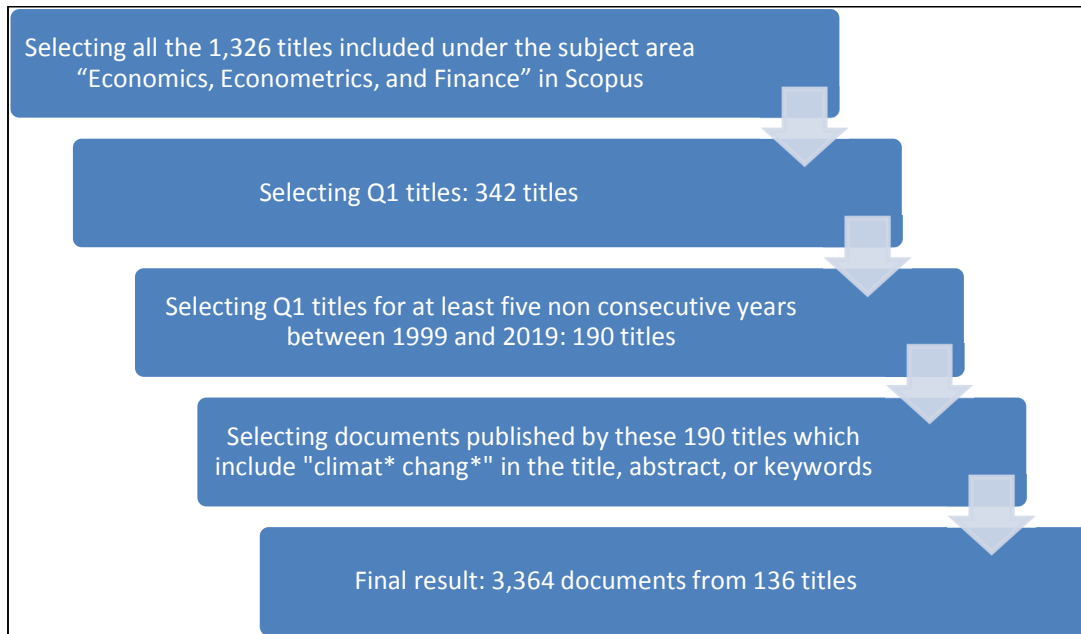
Paul-Hus, 2016). Second, Scopus has been widely used in other bibliometric studies related to climate change (Di Matteo et al., 2018; Lima and Bonetti, 2020).

Regarding the inclusion and exclusion criteria, bibliometrics's main criterion relates to the use of a specific term or expression, or a set of terms/expressions, for identifying the documents published on the topic under investigation (Zupic and Čater, 2015). We searched for “climat* chang*”, which is a truncated expression that could indicate “climate change”, “climate changes”, “climatic change”, and “climatic changes”. These expressions are widely used in the scientific community and they are more neutral in describing the phenomenon and its effects compared to other terms such as “global warming” (Gann and Matlock, 2014). Consistent with the bibliometric literature, our search focused on documents' titles, abstracts, and keywords (Zhu and Liu, 2020).

We concentrated on one of the subject areas identified by Scopus, namely “Economics, Econometrics, and Finance”, which identifies economics journals. Since we were interested in mapping the discussion on climate change in the most influential scientific titles for this subject area, defining a list of leading titles before searching for documents on climate change was important. For each subject area, Scopus provides a ranking of titles based on the titles' SJR index. The first quartile (Q1) of such a ranking identifies the quarter of titles that display the highest SJR values. We considered the Q1 titles in the “Economics, Econometrics, and Finance” subject area as the leading Scopus-indexed economics titles. In March 2021, we counted 342 titles (listed in Appendix 1). Simply considering these titles as leading titles can be misleading; indeed, some of these titles were added to Scopus only recently, while others entered the Q1 only in the last year or couple of years. Hence, we decided to impose an additional threshold; we considered only those titles that were in the Q1 at least for five not necessarily consecutive years between 1999 (the earliest year for observing quartiles in the Scopus-based SCImago website) and 2019 (the latest available year used for calculating the SJR). This 20-years period provides a good overview of the leading titles' ranking evolution in the subject area. After applying this threshold, we obtained a list of 190 titles (listed in Appendix 2).

By relying on the criteria illustrated above, we run our search on Scopus on the 24th of March 2021: we found 3,364 documents from 136 titles, published between 1974 and 2021. We also found a paper published before 1974 in the *Quarterly Journal of Economics* (Huntington, 1917), about climate changes that occurred during the Roman Empire, but it has not been included in our analysis. The data collection process is summarised in Figure 1.

Figure 1. Data collection process in Scopus.



The bibliometric analysis allows to quantitatively assess the scientific literature on a specific research field, using statistical techniques that provide regularity in the review process and support the researchers in understanding the field's evolution (Garfield, 1979; White and Griffith, 1981; Zupic and Čater, 2015). The most common techniques support descriptive analysis and network extraction: in particular, bibliometrics can focus on co-word analysis, co-author analysis, and citation analysis, including co-citation analysis and bibliographic coupling (Aria and Cuccurullo, 2017; Cobo et al., 2011a, 2011b). In this paper, we concentrate on the following steps for addressing our research question:

- 1) a descriptive analysis based on the number of publications, their impact in the literature, and the main economic titles publishing documents on climate change;
- 2) a country's productivity and co-authorship analysis describing cross-country collaboration networks, where a collaboration between two countries (i.e. a link between two countries in a network) occurs when authors affiliated to organizations located in these countries have co-authored a document;
- 3) a content analysis based on authors' keywords. More specifically, we concentrate on keywords' co-occurrence networks (where network nodes are keywords, and a link between two keywords indicates that these keywords are associated with the same document). Furthermore, we analyse the documents' conceptual structure by implementing a multiple correspondence analysis (MCA) and a cluster analysis to define patterns of topics in the literature. Finally, we conclude with an analysis of the thematic evolution.

We used the *bibliometrix* R package (Aria and Cuccurullo, 2017) for the data analysis and visualization.

3. Results

3.1 Published documents

Around 72% (136 over 190) of the leading titles identified throughout the approach described in section 2 published at least one document on climate change from 1974 to 2021. More specifically, over this period, the selected titles published 3,364 relevant documents with, on average, 33 citations per document. The 91.7% of these documents are articles (3,084 documents), 3.6% are reviews (122 documents), 1.8% are conference papers (62 documents), 0.9% are editorials (31 documents), 0.9% are notes (29 documents), 0.7% are short surveys (26 documents), 0.1% are erratum (5 documents), 0.1% are letters (4 documents), and one document is a book chapter. Amongst the most cited documents overall, considering those with more than 500 citations in Scopus (13 documents in total), there are three studies from the 1990s (Holtz-Eakin and Selden, 1995; Neil Adger, 1999; Nordhaus and Yang, 1996) and 10 studies published between 2003 and 2010 (Adger, 2009; Deschênes and Greenstone, 2007; Hanjra and Qureshi, 2010; Kahn, 2005; Nordhaus, 2007; Norgaard, 2010; Peters, 2008; Stern, 2008; Weitzman, 2009, 2007).

Figure 2 shows the evolution of the annual number of the selected documents from 1974 to 2021 (grey bars, left y axis), which can be assumed as a proxy of economists' attention for climate change over time. The figure also displays the incidence of these research outputs on the total number of documents published per year by the titles under scrutiny (black line, right y axis). Looking at the bars in the Figure, the first paper retrieved by our search has been the work of Hoch and Drake (1974) published in the *Journal of Environmental Economics and Management*. From that year until the beginning of the 1990s, we found only a few climate change-related documents indexed in Scopus. According to the data, the economists' interest in the topic started rising evidently from the beginning of the 1990s. This is consistent with previous findings by the scholars who looked at the entire (non-field specific) scientific literature on climate change (Haunschild et al., 2016) and by those who specifically looked at the Social Science literature on climate change (Goodall, 2008). The rise of scholars' interest at the beginning of the 1990s is not surprising. Indeed, the climate-change issue started gaining significant public attention exactly in those years, thanks to the work by the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC), whose first assessment report was released in 1990 (IPCC, 1990), and to the Conference on Environment and Development, held in Rio de Janeiro in 1992. The increase of the economics scientific production on climate change is particularly remarkable from the second part of the 2000s. The trend observed in this period confirms for economics what has been found for other disciplines (Haunschild et al., 2016). The Kyoto Protocol became operational in 2005, after Russia's ratification, and it seems reasonable to assume that this event significantly triggered the scholars' interest in climate change. A further evident increase is observed from 2018, when the Nobel Prize in Economic Sciences was awarded to William Nordhaus, until 2021².

Overall, the bars represented in Figure 2 suggest that the number of economics papers on climate change issues exponentially increased over the last 30 years. Looking at the black line in Figure 2, such an increase in the number of published papers translated into a rise in the importance of climate change-related research in Economics. Nevertheless, the incidence of research on this topic over the total number of published studies is still limited, being higher than 2% only from 2018 onwards. In other words, while climate change has gained interest among economists, we observe a puzzling disinterest by economics publication outlets for such an important issue.

² Data (documents) from 2021 are partial. We carried out our data extraction in March 2021 and we found 161 documents published in the first three months of the year, which is still exceptional compared to the previous years.

Figure 2. climate change- related documents published per year in the selected journals.

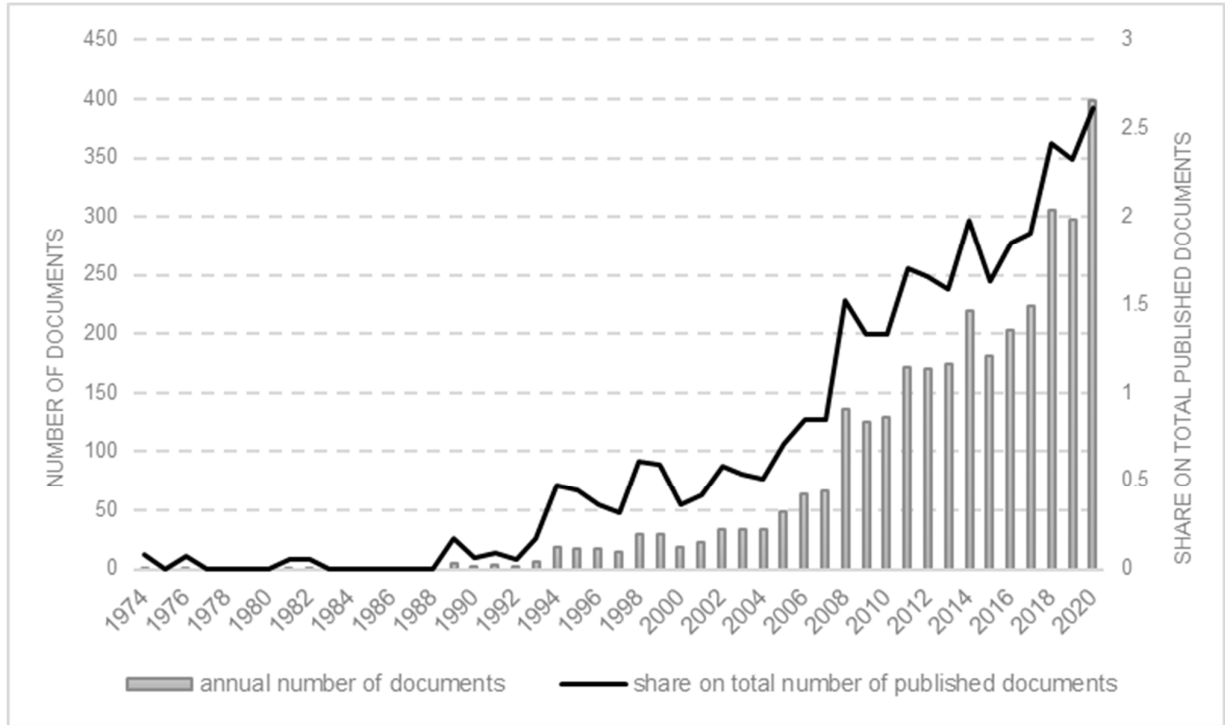


Table 1 lists the ten titles that published the highest absolute number of climate change-related documents over the considered period. Most of these titles have a clear scope in investigating environmental issues and the interrelation between environment and economics; Ecological Economics is the leading journal. None of the journals in Table 1 appears in the so-called FT50 list, compiled by the Financial Times, that has a relevant impact on the business schools' community since publishing in the journals in that list is used for career advancements and attracting research grants (Vidgen et al., 2019). Table 2 illustrates what FT50 titles published documents on climate change during the 1974–2021-time span; the Journal of Business Ethics and the American Economic Review are leading this particular ranking, having published 42 and 22 documents, respectively, while all other FT50 titles published less than five documents each.

Table 1. List of Economics Q1 Scopus indexed publication outlets that published the highest absolute number of climate change-related papers.

Ranking	Title	Number of documents
1	Ecological Economics	559
2	Energy Economics	332
3	Environmental and Resource Economics	304
4	Marine Policy	269
5	Resources, Conservation and Recycling	224
6	Journal of Environmental Economics and Management	159
7	World Development	154
8	Resource and Energy Economics	89
9	GAIA	84
10	Energy Journal	74

Table 2. List of the FT50-indexed journals that published the highest absolute number of climate change-related documents. For each journal the ranking position in the complete list is reported.

Position in the complete ranking	Title	Number of documents
18	Journal of Business Ethics	42
23-25	American Economic Review	22
58-63	Review of Financial Studies	5
64-70	Journal of International Business Studies	4
64-70	Journal of Political Economy	4
71-80	Journal of Financial Economics	3
81-99	Journal of Marketing Research	2
81-99	Review of Economic Studies	2
100-136	Econometrica	1
100-136	Entrepreneurship Theory and Practice	1
100-136	Journal of Financial and Quantitative Analysis	1

3.2 Authors and countries

The documents considered in our analysis are related to 7,051 authors; 818 are single-authored documents, but on average, there are 2.86 co-authors per document. Looking at the country where the corresponding author works, the five most productive countries are the USA, the United Kingdom, Germany, Australia, and China (Figure 3). While the first three countries, together with the Netherlands, have always been leading, in terms of scientific production, China has emerged as a strong contributor only in the last two decades³. A similar ranking can also be found in other topics discussed in the economics and business literature, such as creativity (Castillo-Vergara et al., 2018), crowdfunding (Martínez-Climent et al., 2018), and circular economy (Ruiz-Real et al., 2018), amongst others. Corresponding authors from the USA have published more than double of the documents from their peers located in the United Kingdom, the second most productive country: 763 from the USA, 332 from the United Kingdom. However, the USA has the lowest Multiple Country Publications (MCP) ratio compared to the other nine most productive countries. For each country (Table 3), this ratio is computed as the number of multiple country documents (i.e., documents where corresponding authors from that country have co-authors from other countries) over the total number of documents. Countries with high scores can be considered as the most active in international collaborations. When considering the top 10 most productive countries, China, Spain, and the Netherlands have the highest MDP ratio scores. These results confirm the main findings by Li et al. (2011) and Nalau and Verrall (2021); Anglo-Saxon countries are still leading the research on climate change, but in recent years China has emerged as a cutting-edge country on this topic, in some cases throughout the establishment of international research-based connections.

³ Detailed data available upon request to the authors.

Figure 3. Most productive countries.

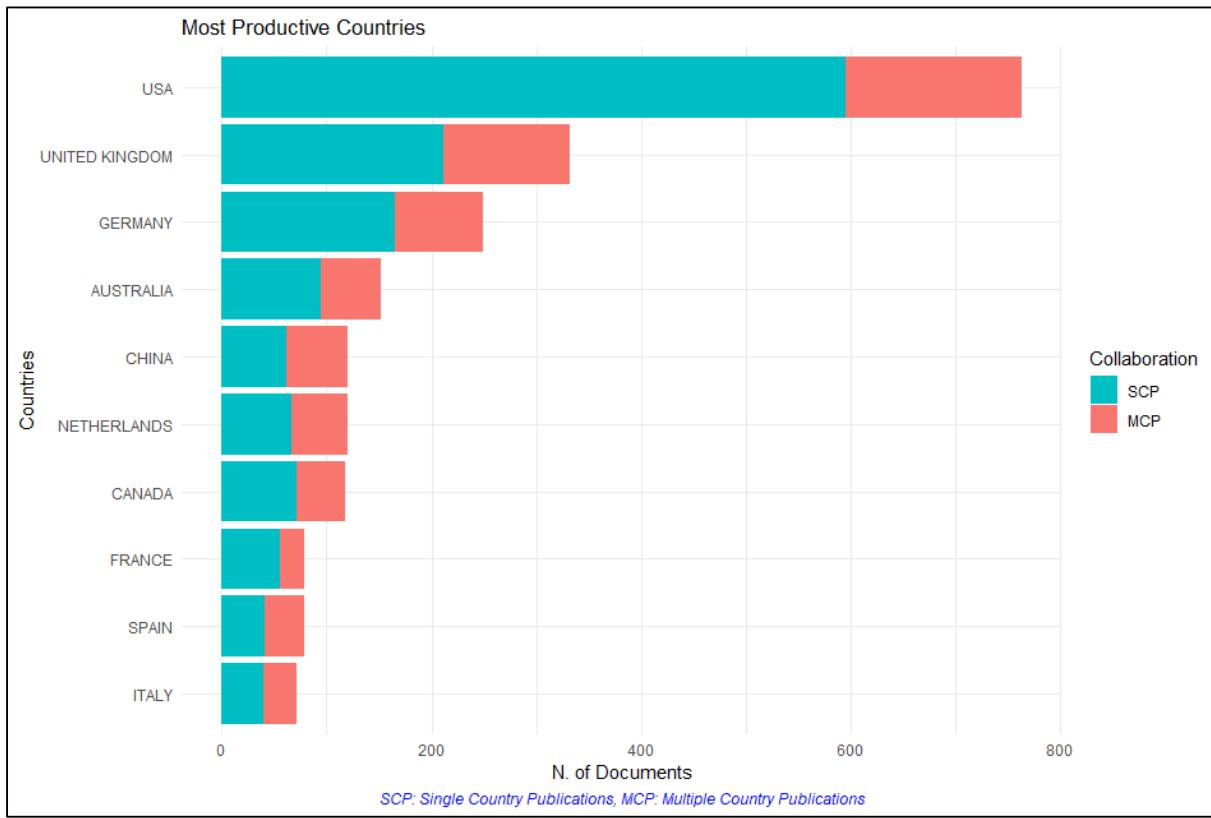


Table 3. MCP ratio for the 10 most productive countries.

Country	Documents	Frequency (over the total of documents)	SCP (Single Country Publications)	MCP (Multiple Country Publications)	MCP ratio (MCP/Documents)
USA	763	0.28	595	168	0.22
United Kingdom	332	0.12	212	120	0.36
Germany	249	0.09	165	84	0.34
Australia	152	0.06	95	57	0.38
China	120	0.04	62	58	0.48
Netherlands	120	0.04	66	54	0.45
Canada	118	0.04	72	46	0.39
France	79	0.03	56	23	0.29
Spain	79	0.03	41	38	0.48
Italy	72	0.03	40	32	0.44

Figures 4-5 illustrate the co-authorship networks created using the above information on cross-country collaborations. The first graph (Figure 4) represents the entire global network; some of the countries are peripheral in the network (e.g., Bahrain, Barbados, Iran, Mongolia, North Korea, and Rwanda), while others are more central (e.g., Germany, USA, United Kingdom, and the USA).

Moreover, some countries have no relationships, such as Ecuador, Iraq, Kazakhstan, Mauritius, and Uruguay. The second graphs (Figure 5) focus on the core of the network represented in Figure 4. It provides a better understanding of the dense cloud of collaborations amongst the most central countries, including the first 40 countries by number of documents: researchers located in South and East European countries (Czech Republic, Greece, Malta, Poland, Romania, and Slovenia) developed their cluster, while those located in African countries (Cameroon, Ethiopia, and Kenya) - together with two countries that are particularly vulnerable to natural hazards such as Indonesia and Mexico (Djalante and Thomalla, 2012; Michetti and Ghinoi, 2020) - have formed a small sub-network connected to South Africa, an important research hub according to the scientific production on the topic.

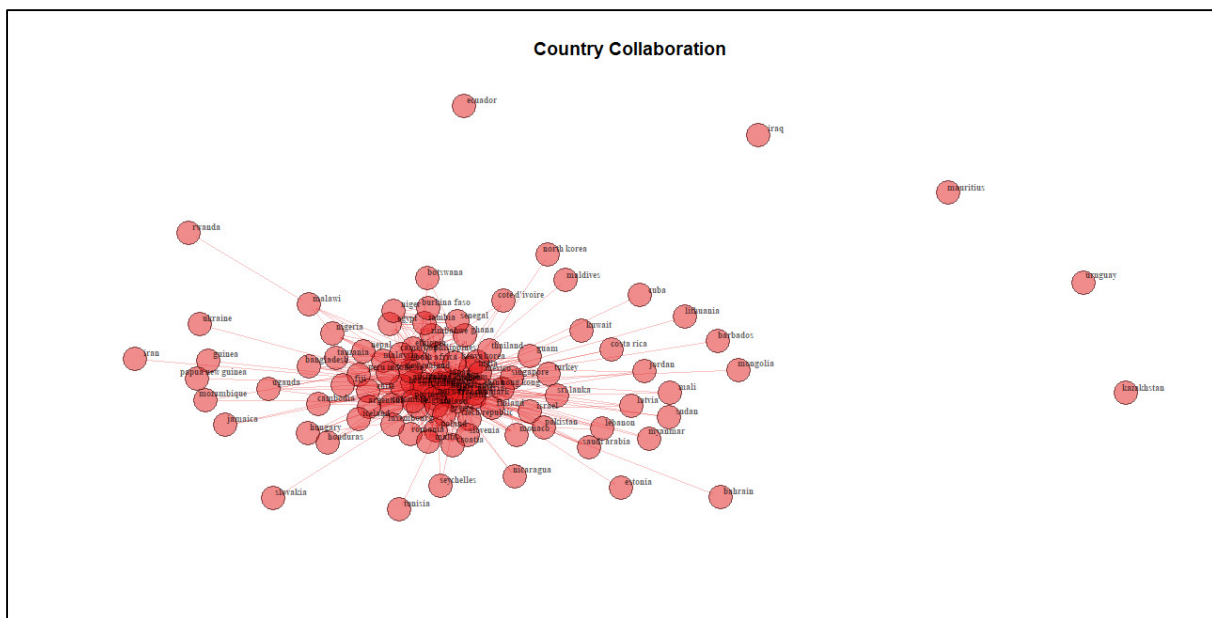
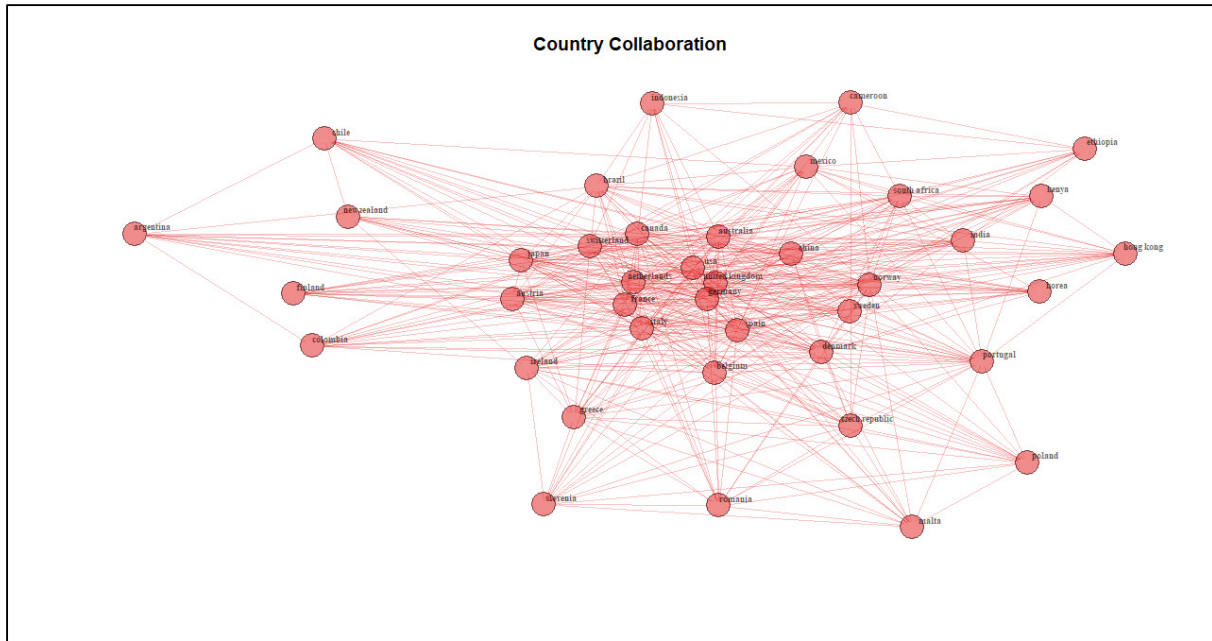


Figure 5. Network of cross-country collaborations – documents co-authorship: first 40 countries by number of documents.



3.3 Keywords and content analysis

Studying keywords and their co-occurrence in abstracts is particularly valuable to understand documents' content. Table 4 lists the most used keywords in the documents under investigation. Not surprisingly, “climate change” is the most common keyword (cited in 1,300 documents), followed by “adaptation”, which is associated to 178 documents, and “climate policy”, which is linked to 110 documents.

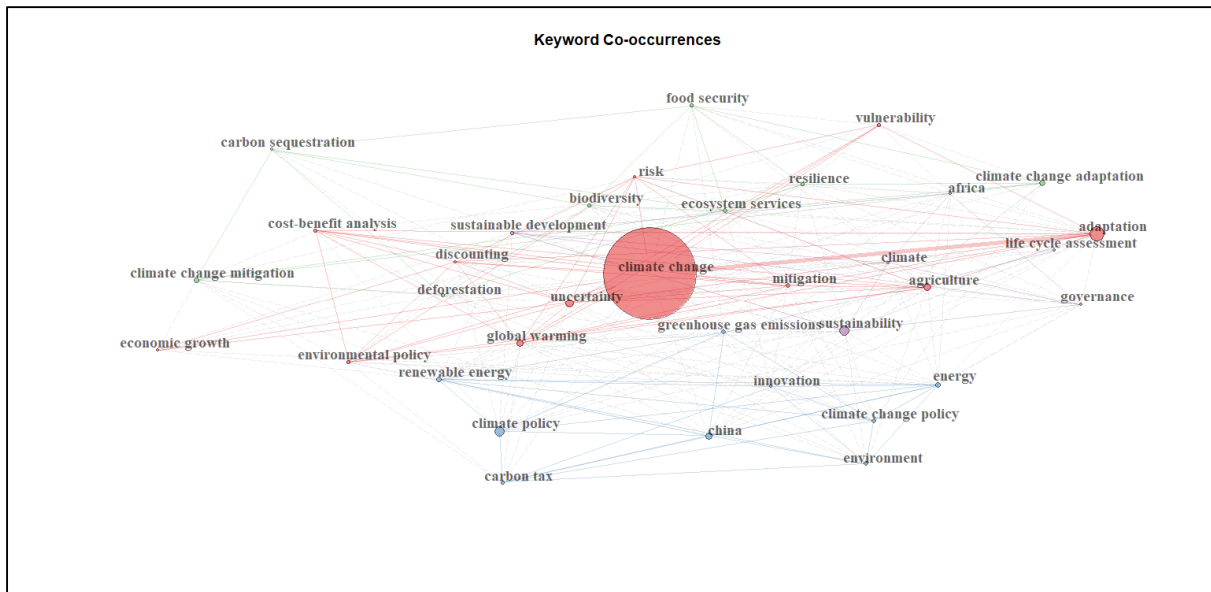
It is interesting to observe that “mitigation” is associated with only 46 documents, albeit adaptation and mitigation measures are considered the macro-categories under which classifying the policies and the programs for tackling climate change (Gupta, 2010). This is probably due to the changes occurring in the political debate and in the scientific community in the 21st century, which has seen increased attention to adaptation measures. During the 1990s, instead, the main focus was on mitigation measures (Javeline, 2014). Since most of the documents examined in this study have been published after 2000, this is consistent with our interpretation. Even considering “climate change adaptation” and “climate change mitigation”, the result does not change, and adaptation is still prevalent with respect to mitigation. “Climate policy” is in third position. This keyword suggests a tangible interest of economic science in assessing activities and designing actions to address climate change issues (e.g., Gowdy, 2008). Therefore, it is not surprising to see it and other related keywords (such as “carbon tax” and “environmental policy”) in Table 4.

Table 4. Most used keywords.

Author keywords		
Ranking	Keyword	Documents
1	Climate change	1,300
2	Adaptation	178
3	Climate policy	110
4	Uncertainty	98
5	Sustainability	88
6	Agriculture	80
7	China	69
8	Global warming	66
9	Renewable energy	56
10	Energy	55
11	Environment	51
12	Mitigation	46
13-14	Climate change adaptation	45
13-14	Environmental policy	45
15	Climate change mitigation	44
16	Greenhouse gas emissions	41
17	Carbon tax	40
18-19	Food security	39
18-19	Sustainable development	39
20-21	Climate change policy	38
20-21	Ecosystem services	38
22	Carbon sequestration	37
23-24	Resilience	36
23-24	Vulnerability	36
25-27	Africa	34
25-27	Cost-benefit analysis	34
25-27	Discounting	34
28	Economic growth	33
29-31	Deforestation	32
29-31	Fisheries	32
29-31	Risk	32

If we consider the list of the most used keywords and we look at their co-occurrences network (Figure 6), i.e. how often keywords co-occur in the same document's abstract, we can detect two peculiar groups (groups have been created by using the Louvain cluster method). One characterized by blue node keywords such as “carbon tax”, “China”, “climate change policy”, “climate policy”, “greenhouse gas emissions”, “energy”, “environment”, “innovation”, and “renewable energy”; and another peripheral group defined by green node keywords such as “carbon sequestration”, “climate change adaptation”, “climate change mitigation”, “deforestation”, “ecosystem services”, “food security”, and “resilience”. The former indicates the presence of a strong interrelation between documents focusing on policy-making, innovation, and energetic issues. The inclusion of the keyword “China” is illustrative of the policy initiatives of this country, which concentrate on energy saving and pollution reduction (Ye Qi et al., 2008); on the other hand, the latter highlights that hard-science keywords linked to biology and agriculture tend to cluster together, while at the same time they are linked to keywords relating to adaptation and mitigation measures.

Figure 6: Keyword co-occurrences.



Note: nodes are proportional to the number of documents associated to each keyword; tie strength relates to the number of co-occurrences between keywords.

The next step consisted of conducting an extended content analysis of the literature themes, using authors' keywords associated with each document for detecting conceptual structures and thematic clusters. The analysis of the conceptual structure (Figure 7) contributes to a better understanding of the most investigated themes in the literature, which are included in the largest clusters. By applying a joint MCA and cluster analysis, we found seven clusters, where the majority of keywords are included in four clusters. In comparison, the other three additional clusters include only a few keywords. Figure 7 illustrates the variance explained by the MCA's first two dimensions: with a value greater than 48%, these dimensions explain the largest share of variance of the whole dataset. The largest cluster (in green) includes the largest number of keywords included in the literature. These keywords are heterogeneous and cover a wide range of themes, with a prevalence of those related to socio-economic disciplines, such as "economic growth", "willingness to pay", "carbon tax", "carbon pricing", "governance", and "international trade", but also natural sciences-based keywords such as "greenhouse gas emission", "deforestation", and "carbon sequestration". A second cluster, represented in orange on the right side of the figure, includes keywords related to the mitigation approach through technological innovation, such as "energy efficiency", "technological change", "carbon emissions", and "renewable energy". This confirms the presence of consistent, and sometimes controversial, literature focused on the role of technological innovation to mitigate the consequences of climate change (Kallis and Bliss, 2019; Sconfienza, 2019; Symons and Karlsson, 2018). The third most relevant cluster (in pink, at the bottom of the figure) includes keywords related to climate change adaptation through the implementation of ecosystem services and the support of biodiversity. "Africa", "food security", and "resilience" are also part of this cluster, which demonstrates the literature's interest for the impact of food policies and the development of ecosystem services also in Africa, especially those related to food security in rural areas (Ahmed, 2020; Davies et al., 2020; Leal Filho et al., 2021; Santarém et al., 2021). Another cluster includes keywords related

to analytical methods (the purple cluster at the top of the figure), such as “discounting”, “cost-benefit analysis”, and “integrated assessment”.

The remaining four clusters can be considered niche clusters. Still, it is interesting that the “climate change” keyword (belonging to the red cluster) is not included in one of the major clusters. Apparently, there is a sort of mismatch between the green and the red cluster because they are proximate but not merged as expected. Moreover, another mismatch is visible between the pink cluster and the blue cluster. The latter includes keywords related to agriculture and adaptation in African countries (“Ethiopia” is one of the keywords highlighted here), which overlap the themes to which are related the keywords of the former. Indeed, Ethiopia is a relevant case study country because of the nexus between agriculture, vulnerability, and adaptation strategies because of its governments’ food-related policies (Shikur, 2020).

Figure 7. Conceptual structure.

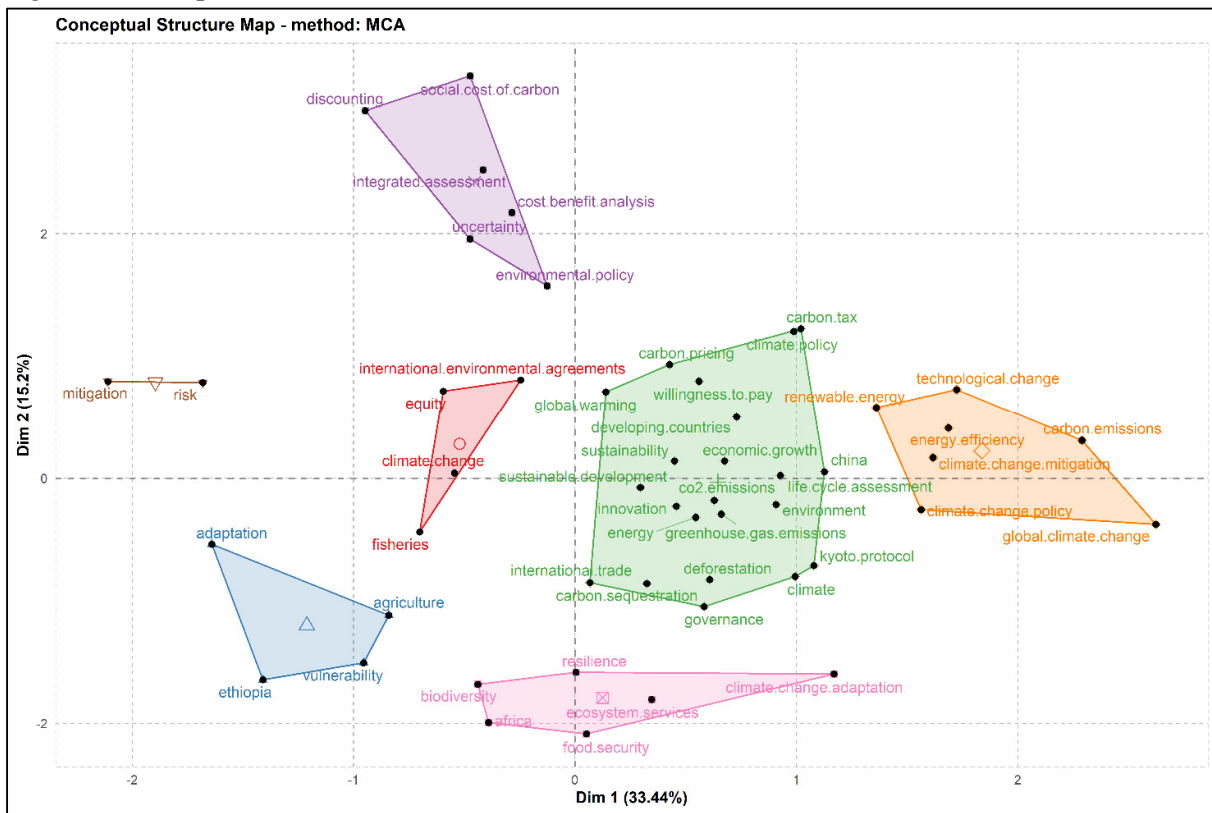
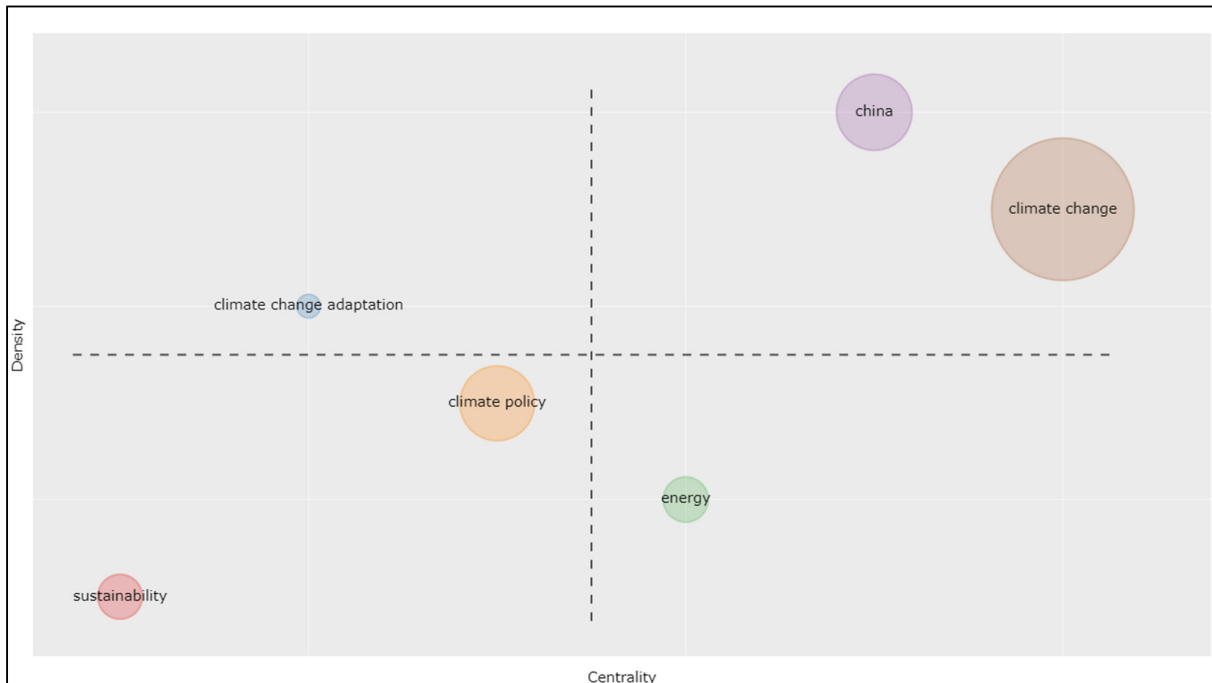


Figure 8 (Strategic Diagram) illustrates the results from the thematic analysis. The identification of thematic clusters was based on the author’s keywords observed at least five times in the documents. The diameter of the bubbles depicted in Figure 10 is directly proportional to the number of documents included in the thematic cluster. The themes have been plotted according to the Callon’s centrality scores, which define the relevance of the topics, and their density scores, describing the degree of development of the literature themes (Cahlik, 2000; Cobo et al., 2011a, 2011b). The combination of centrality and density scores allows defining the thematic clusters’ position in the overall literature debate. Namely, low scores of centrality and density determine the emerging or declining themes, depending on their evolution over time, that are not still (or anymore) central in the research field. Low density score and high centrality score identify the basic themes which are discussed in the

considered documents. High density scores and low centrality scores define niche themes discussed in a significant minority of documents with a limited impact on the overall discussion. Finally, high scores for density and centrality identify the motor themes well developed within the discussion.

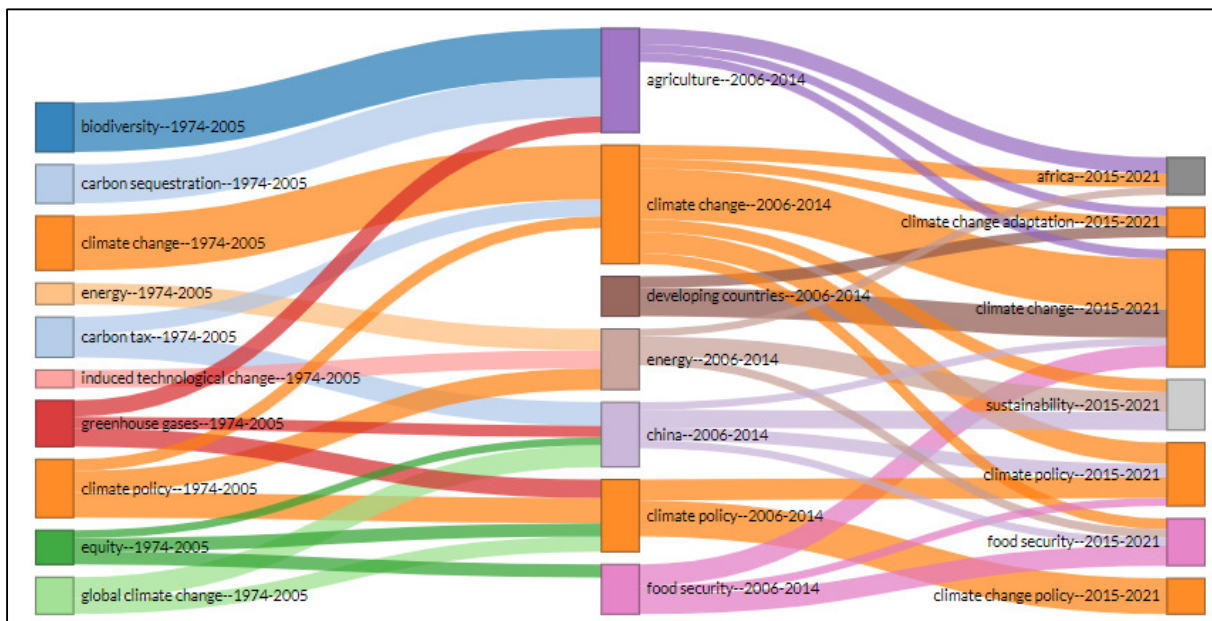
We have identified seven different clusters, labelled by the most frequent keywords (the complete list of keywords is available upon request). The emerging themes, represented in the lower left quadrant, are collected within two clusters, identified by the “sustainability” and “climate policy” keywords. The low centrality of the two clusters is probably due to recent development within the economics literature. The niche themes, represented in the upper left quadrant, belong to a small cluster identified by the “climate change adaptation” keyword. As for the emerging themes, climate change adaptation is, as anticipated in previous sections, a relatively recent theme (Javeline, 2014), but it presents a higher level of development. Together with the positioning of the cluster in the strategic diagram, these two aspects allow identifying this theme as well developed in terms of internal ties, but with a low number of connections with other themes. The basic themes central in the debate but still undeveloped, are represented in the lower right quadrant of Figure 10 by the “energy” cluster. Energy-related issues are deeply discussed in hard sciences. Their discussion in the socio-economic literature is relatively recent and can be linked to the emergence of an eco-modernist approach (Asafu-Adjaye et al., 2015; Sagoff, 2018). So, this could be the reason for the low development of this cluster. Finally, those themes with a higher stage of development and which are more central in the literature are represented in the upper right quadrant. They are identified by clusters defined by the keywords “climate change” and “China”. Regarding the former, this result indicates that the most consolidated themes discussed in the literature have a quite generalist nature since the keyword “climate change” relates to different fields, both from the socio-economic sciences and the natural sciences. On the other hand, the cluster “China” shows that the literature on emissions reduction has concentrated on the Chinese context in the last years. This country is considered the major global contributor to CO₂ emissions alongside the US. This situation has led to the increasing relevance of the studies concerning this Asian country (Friedlingstein et al., 2020).

Figure 8. Strategic Diagram of thematic clusters.



The analysis of the thematic evolution (Figure 9) describes the progress over time of the themes explored within the documents included in this analysis and shed light on the direction taken by the climate change literature over the years. The study of the thematic evolution allows describing the tendencies of themes to converge or diverge over time, revealing the persistence of specific themes in different periods and the emergence of new thematic clusters (Aria and Cuccurullo, 2017; Cobo et al., 2011a). In this analysis, we focused on the three different periods, divided by the 2005 and 2014 cut-off years, that were identified in section 3 through our inspection of the trend of the climate change-related publications in the set of journals under investigation.

Figure 9: Thematic evolution.



In the first time slice, going from 1974 to 2005, we identified the predominance of themes related to the natural sciences and the technological domain. Indeed, only three themes out of the ten identified, labelled using the keywords “carbon tax”, “equity”, and “climate policy” can be strictly linked to the socio-economic and political domain. The second period, going from 2006 to 2014, shows the emergence of new themes, and the confluence of the old ones into the new ones. The persistent thematic clusters are “climate change” and “climate policy”, which register the confluence of documents focusing on themes such as “climate policy”, “carbon tax”, “greenhouse gases”, “equity”, and “global climate change”. The emerging themes include topics like “food security”, “agriculture”, “energy”, “China”, and “developing countries”. The last period, going from 2015 to 2021, is characterized by the persistence of themes identified by the keywords “climate policy”, “climate change”, and “food security”. Among the new themes, we identify those related to “climate change policy” (deriving from “climate policy”), “sustainability” (deriving from “China”, “energy”, and “climate change”), “climate change adaptation”, and “Africa” (deriving from “developing countries”, “agriculture”, and “climate change”).

4. Conclusions

In this work, we applied a bibliometric approach to assessing the relevance of climate change in the economic literature of the last five decades. On the one hand, the method for selecting the documents to be considered in our analysis brings out the most recognized titles in the field of environmental economics (e.g., *Ecological Economics*, *Environmental and Resource Economics*, the *Journal of Environmental Economics and Management*) as the natural space for the debate on climate change. Among these journals, it emerges the presence of more sectoral journals focusing on energy issues (e.g., *Energy Economics* and *Resource and Energy Economics*), an aspect that in economics is strongly associated with climate change (Dell et al., 2014). On the other hand, the analysis highlights the low diffusion of a debate on these issues among FT50 titles, apart from the *Journal of Business Ethics*, whose attention for climate change attests to the environment's perception as an ethical issue by economic science (Crane et al., 2019). The *American Economic Review*, which published 22 documents on climate change from 1982 to 2019, and almost a quarter of them are due to William Nordhaus, who received the Nobel Prize in Economic Sciences in 2018 for integrating climate change into long-run macroeconomic analysis.

Considering 1974-2021 as a time span allows understanding how the perception and the study of climate change in economics modified over time. In this vein, it must be highlighted a parallel between scientific production and international policy-related events. Such a parallel is visible when looking at the continuous increase in the number of documents published from 1992, the year of Rio's Earth summit, with a first acceleration around 2005 (when the Kyoto Protocol became operational after Russia's ratification), and a second one around 2014, when the prospect of the Paris Agreement of December 2015 became progressively more effective.

Our results show that the United States, the United Kingdom, and Germany are the most productive countries in terms of scientific production, thus authors from these countries do not have the same attitude to collaborating internationally. Moreover, China is emerging as a leading country on climate change research. Its global relevance is reflected by the fact that “China” is amongst the 10 most quoted keywords in the examined documents. There is also another geographical keyword emerging from the analysis: “Africa”. This result confirms the historically established focus of the scientific community on this continent because, despite African countries are low emitters of greenhouse gases, they are suffering from the adverse effects of climate change more than other countries from the

global north (Low 2005). However, we have not found a sound collaboration network from authors based in African countries; this finding confirms an aspect recently discussed in the scientific literature: the lack of resources for investigating climate change in these countries (Hendrix 2017). Finally, we have detected a change of themes within the climate change literature over time. In this perspective, we can identify three different phases: a pioneering one (1974-2005), with debated themes primarily focusing on aspects related to the natural sciences. In the central period (2006-2014), debated themes grow noticeably, emphasizing analytical instruments such as economic modeling and methodologic approaches. Not surprisingly, during the last period (2015-2021), the analytical effort has left the scene to themes linked to the definition and implementation of policies, with a relevant number of keywords that reflect the distinction between adaption and mitigation measures (Gupta, 2010). Our interpretation is that climate change is finally perceived as a global challenge, as testified by its recent correlation with concepts like food supply and public health, to be addressed with a policy-oriented approach beyond pure analytical methods.

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Appendix 1

List of Q1 titles for “*Economics, Econometrics, and Finance*” in Scopus (March 2021) (n=342).

Titles		
Accounting and Finance	Financial Accountability and Management	Journal of Labor Economics
Accounting Forum	Financial History Review	Journal of Law and Economics
Accounting Review	Financial Innovation	Journal of Law, Economics, and Organization
Accounting, Auditing and Accountability Journal	Financial Management	Journal of Law, Finance, and Accounting
African Economic History	Fiscal Studies	Journal of Management
African Journal of Economic and Management Studies	Food Policy	Journal of Marketing Research
Agribusiness	Foresight and STI Governance	Journal of Monetary Economics
Agricultural and Food Economics	Forest Policy and Economics	Journal of Money, Credit and Banking
Agricultural Economics (Czech Republic)	Foundations and Trends in Accounting	Journal of Multinational Financial Management
Agricultural Economics (United Kingdom)	Foundations and Trends in Entrepreneurship	Journal of Open Innovation: Technology, Market, and Complexity
Agricultural Finance Review	GAIA	Journal of Political Economy
American Economic Journal: Applied Economics	Global Policy	Journal of Population Economics
American Economic Journal: Economic Policy	Globalizations	Journal of Productivity Analysis
American Economic Journal: Macroeconomics	Handbook of Computational Economics	Journal of Property Investment and Finance
American Economic Journal: Microeconomics	Historical Materialism	Journal of Public Economics
American Economic Review	History of Economic Ideas	Journal of Public Policy and Marketing
American Journal of Agricultural Economics	History of Political Economy	Journal of Real Estate Research
American Law and Economics Review	ICSID Review	Journal of Risk and Insurance
Annals of Public and Cooperative Economics	IMA Journal of Management Mathematics	Journal of Risk and Uncertainty
Annual Review of Economics	IMF Economic Review	Journal of Self-Governance and Management Economics
Annual Review of Financial Economics	Indian Economic and Social History Review	Journal of Social Ontology
Annual Review of Resource Economics	Industrial and Corporate Change	Journal of South Asian Development
Applied Economic Perspectives and Policy	Innovation Policy and the Economy	Journal of Sports Economics
Applied Health Economics and Health Policy	Insurance: Mathematics and Economics	Journal of Supply Chain Management
Asia and the Pacific Policy Studies	Intellectual Economics	Journal of the Academy of Marketing Science

Asia Pacific Journal of Management	Intelligent Systems in Accounting, Finance and Management	Journal of the Association of Environmental and Resource Economists
Asian Economic Policy Review	International Business Review	Journal of the Economic and Social History of the Orient
Auditing	International Economics	Journal of the European Economic Association
Australasian Accounting, Business and Finance Journal	International Environmental Agreements: Politics, Law and Economics	Journal of the History of Economic Thought
Australian Economic History Review	International Journal of Accounting	Journal of the Knowledge Economy
Baltic Region	International Journal of Accounting and Information Management	Journal of the Royal Statistical Society. Series A: Statistics in Society
Borsa Istanbul Review	International Journal of Accounting Information Systems	Journal of Urban Economics
Brookings Papers on Economic Activity	International Journal of Agricultural Sustainability	Journal of World Business
BRQ Business Research Quarterly	International Journal of Auditing	Judgment and Decision Making
Bulletin of Indonesian Economic Studies	International Journal of Biological Macromolecules	Kyklos
Business Ethics	International Journal of Business Communication	Land Economics
Business Ethics Quarterly	International Journal of Consumer Studies	Latin American Research Review
Cambridge Journal of Economics	International Journal of Contemporary Iraqi Studies	Library of Economic History
Cambridge Journal of Regions, Economy and Society	International Journal of Electronic Commerce	Local Economy
Capital and Class	International Journal of Energy Economics and Policy	Long Range Planning
China and World Economy	International Journal of Ethics and Systems	Management Accounting Research
China Economic Journal	International Journal of Gender and Entrepreneurship	Managerial Auditing Journal
China Economic Review	International Journal of Production Economics	Marine Policy
China Information	International Relations of the Asia-Pacific	Marine Resource Economics
City, Culture and Society	International Review of Economics and Finance	Maritime Economics and Logistics
ClinicoEconomics and Outcomes Research	International Review of Environmental and Resource Economics	Marketing Letters
Cliometrica	International Review of Financial Analysis	Mathematical Finance
Conflict Management and Peace Science	Internet Research	Mind and Society
Constitutional Political Economy	IZA Journal of Labor Policy	MIS Quarterly Executive
Consumption Markets and Culture	Journal of Accounting and Economics	Montenegrin Journal of Economics

Contemporary Accounting Research	Journal of Accounting Research	National Institute Economic Review
Contemporary Economics	Journal of Accounting, Auditing and Finance	NBER Macroeconomics Annual
Critical Perspectives on Accounting	Journal of Advanced Transportation	New Economic Windows
Development Engineering	Journal of Agricultural Economics	New Perspectives on Turkey
E a M: Economie a Management	Journal of Applied Econometrics	Nonlinear Analysis: Real World Applications
Eastern Journal of European Studies	Journal of Asia Business Studies	Oxford Review of Economic Policy
Ecological Economics	Journal of Banking and Finance	Pacific Basin Finance Journal
Econometrica	Journal of Behavioral and Experimental Economics	Palgrave Communications
Econometrics Journal	Journal of Business and Economic Statistics	Politics, Philosophy and Economics
Economic Analysis and Policy	Journal of Business Economics	Post-Soviet Affairs
Economic Development and Cultural Change	Journal of Business Economics and Management	Public Policy and Administration
Economic Geography	Journal of Business Ethics	Quantitative Finance
Economic History of Developing Regions	Journal of Business Finance and Accounting	Quarterly Journal of Economics
Economic History Review	Journal of Commodity Markets	RAND Journal of Economics
Economic Journal	Journal of Common Market Studies	Regional Science and Urban Economics
Economic Modelling	Journal of Comparative Economics	Regional Studies, Regional Science
Economic Policy	Journal of Consumer Affairs	Research in International Business and Finance
Economic Systems	Journal of Consumer Culture	Research in Political Economy
Economic Systems Research	Journal of Consumer Research	Research in the History of Economic Thought and Methodology
Economica	Journal of Contemporary Central and Eastern Europe	Research in Transportation Business and Management
Economics and Human Biology	Journal of Corporate Finance	Research in Transportation Economics
Economics and Philosophy	Journal of Corporate Real Estate	Resources and Energy Economics
Economics and Sociology	Journal of Cultural Economics	Resources Policy
Economics of Education Review	Journal of Cultural Heritage	Resources, Conservation and Recycling
Economics of Energy and Environmental Policy	Journal of Development Economics	Review of Corporate Finance Studies
Economics of Innovation and New Technology	Journal of Econometrics	Review of Development Finance
Economics of Transportation	Journal of Economic Geography	Review of Economic Dynamics
Economics, Management, and Financial Markets	Journal of Economic Growth	Review of Economic Studies
Economy and Society	Journal of Economic History	Review of Economics and Statistics
Electronic Commerce Research	Journal of Economic Inequality	Review of Environmental Economics and Policy
Electronic Markets	Journal of Economic Literature	Review of Finance

Emerging Markets Finance and Trade	Journal of Economic Methodology	Review of Financial Studies
Emerging Markets Review	Journal of Economic Perspectives	Review of International Organizations
Empirical Economics	Journal of Economic Policy Reform	Review of International Political Economy
Energy Economics	Journal of Economic Psychology	Review of Radical Political Economics
Energy Journal	Journal of Economic Studies	Review of World Economics
Energy Systems	Journal of Economic Surveys	Revista de Historia Economica - Journal of Iberian and Latin American Economic History
Entrepreneurship and Regional Development	Journal of Economics, Finance and Administrative Science	Rivista di Studi sulla Sostenibilita
Entrepreneurship and Sustainability Issues Open Access	Journal of Electronic Commerce Research	Scandinavian Actuarial Journal
Entrepreneurship: Theory and Practice	Journal of Empirical Finance	Science Technology and Human Values
Environment, Development and Sustainability	Journal of Entrepreneurship Education	Small Business Economics
Environmental and Resource Economics	Journal of Entrepreneurship in Emerging Economies	Socio-Economic Planning Sciences
Eurasian Business Review	Journal of Environmental Economics and Management	Socio-Economic Review
Eurasian Geography and Economics	Journal of Family Business Strategy	South Asia Research
EuroMed Journal of Business	Journal of Finance	South Asian Journal of Business Studies
European Accounting Review	Journal of Financial and Quantitative Analysis	Space and Culture, India
European Economic Review	Journal of Financial Economics	Spatial Economic Analysis
European Financial Management	Journal of Financial Intermediation	Strategic Entrepreneurship Journal
European Journal of Health Economics	Journal of Financial Markets	Structural Equation Modeling
European Journal of Law and Economics	Journal of Financial Services Research	Technological and Economic Development of Economy
European Journal of Management and Business Economics	Journal of Financial Stability	Terra Economicus
European Journal of Political Economy	Journal of Human Capital	Theoretical Economics
European Journal of the History of Economic Thought	Journal of Human Resources	Transformations in Business and Economics
European Research on Management and Business Economics	Journal of Innovation and Entrepreneurship	Transnational Corporations
European Review of Agricultural Economics	Journal of Innovation and Knowledge	Valori e Valutazioni
European Review of Economic History	Journal of Institutional Economics	Value in Health Regional Issues
Europe-Asia Studies	Journal of International Business Studies	Venture Capital

Experimental Economics	Journal of International Economic Law	Wine Economics and Policy
Explorations in Economic History	Journal of International Economics	Work, Aging and Retirement
Extremes	Journal of International Financial Management and Accounting	Work, Employment and Society
Family Business Review	Journal of International Financial Markets, Institutions and Money	World Bank Economic Review
Feminist Economics	Journal of International Management	World Bank Research Observer
Finance and Stochastics	Journal of International Money and Finance	World Development
Finance Research Letters	Journal of International Studies	Young Consumers

Appendix 2

List of leading titles (n=190) and titles included in our analysis (n=136). The latter constitute a subgroup of the former: they are highlighted in bold and underlined.

Titles				
<u>Accounting Review</u>	<u>Energy Economics</u>	<u>Journal of Accounting, Auditing and Finance</u>	<u>Journal of Institutional Economics</u>	<u>Mathematical Finance</u>
<u>Accounting, Auditing and Accountability Journal</u>	<u>Energy Journal</u>	<u>Journal of Agricultural Economics</u>	<u>Journal of International Business Studies</u>	MIS Quarterly Executive
<u>Agricultural Economics (United Kingdom)</u>	<u>Entrepreneurship and Regional Development</u>	<u>Journal of Applied Econometrics</u>	<u>Journal of International Economic Law</u>	<u>NBER Macroeconomics Annual</u>
<u>American Economic Journal: Applied Economics</u>	<u>Entrepreneurship: Theory and Practice</u>	<u>Journal of Banking and Finance</u>	<u>Journal of International Economics</u>	<u>Nonlinear Analysis: Real World Applications</u>
<u>American Economic Journal: Economic Policy</u>	<u>Environmental and Resource Economics</u>	Journal of Business and Economic Statistics	<u>Journal of International Financial Markets, Institutions and Money</u>	<u>Oxford Review of Economic Policy</u>
American Economic Journal: Macroeconomics	Eurasian Business Review	<u>Journal of Business Ethics</u>	Journal of International Management	Post-Soviet Affairs
American Economic Journal: Microeconomics	<u>European Economic Review</u>	<u>Journal of Business Finance and Accounting</u>	Journal of International Money and Finance	Quantitative Finance
<u>American Economic Review</u>	European Financial Management	<u>Journal of Common Market Studies</u>	<u>Journal of Labor Economics</u>	<u>Quarterly Journal of Economics</u>
<u>American Journal of Agricultural Economics</u>	European Journal of Health Economics	<u>Journal of Comparative Economics</u>	Journal of Law and Economics	RAND Journal of Economics
American Law and Economics Review	<u>European Journal of Political Economy</u>	Journal of Consumer Affairs	Journal of Law, Economics, and Organization	<u>Regional Science and Urban Economics</u>
<u>Annual Review of Economics</u>	<u>European Review of Agricultural Economics</u>	<u>Journal of Consumer Culture</u>	Journal of Management	<u>Research in Transportation Business and Management</u>
Annual Review of Financial Economics	<u>European Review of Economic History</u>	Journal of Consumer Research	<u>Journal of Marketing Research</u>	<u>Research in Transportation Economics</u>
<u>Annual Review of Resource Economics</u>	<u>Experimental Economics</u>	<u>Journal of Corporate Finance</u>	<u>Journal of Monetary Economics</u>	<u>Resources and Energy Economics</u>
<u>Asia Pacific Journal of Management</u>	<u>Explorations in Economic History</u>	<u>Journal of Cultural Economics</u>	Journal of Money, Credit and Banking	<u>Resources, Conservation and Recycling</u>
<u>Auditing</u>	<u>Extremes</u>	<u>Journal of Development Economics</u>	<u>Journal of Political Economy</u>	<u>Review of Economic Dynamics</u>
<u>Brookings Papers on Economic Activity</u>	Family Business Review	<u>Journal of Econometrics</u>	<u>Journal of Population Economics</u>	<u>Review of Economic Studies</u>
<u>Business Ethics Quarterly</u>	Finance and Stochastics	<u>Journal of Economic Geography</u>	<u>Journal of Productivity Analysis</u>	<u>Review of Economics and Statistics</u>
<u>Cambridge Journal of Regions, Economy and Society</u>	Financial Management	<u>Journal of Economic Growth</u>	<u>Journal of Property Investment and Finance</u>	<u>Review of Environmental Economics and Policy</u>
<u>China and World Economy</u>	<u>Food Policy</u>	<u>Journal of Economic History</u>	<u>Journal of Public Economics</u>	Review of Finance
ClinicoEconomics and Outcomes Research	Foundations and Trends in Accounting	Journal of Economic Inequality	<u>Journal of Public Policy and Marketing</u>	<u>Review of Financial Studies</u>
Conflict Management and Peace Science	Foundations and Trends in Entrepreneurship	<u>Journal of Economic Literature</u>	Journal of Real Estate Research	<u>Review of International Organizations</u>

Contemporary Accounting Research	<u>GAIA</u>	<u>Journal of Economic Methodology</u>	Journal of Risk and Insurance	<u>Review of International Political Economy</u>
<u>Critical Perspectives on Accounting</u>	<u>Globalizations</u>	<u>Journal of Economic Perspectives</u>	<u>Journal of Risk and Uncertainty</u>	<u>Review of World Economics</u>
<u>Ecological Economics</u>	<u>Historical Materialism</u>	<u>Journal of Economic Psychology</u>	Journal of Sports Economics	<u>Scandinavian Actuarial Journal</u>
<u>Econometrica</u>	IMA Journal of Management Mathematics	<u>Journal of Economic Studies</u>	<u>Journal of Supply Chain Management</u>	<u>Science Technology and Human Values</u>
<u>Econometrics Journal</u>	IMF Economic Review	<u>Journal of Economic Surveys</u>	Journal of the Academy of Marketing Science	Small Business Economics
<u>Economic Development and Cultural Change</u>	<u>Industrial and Corporate Change</u>	Journal of Electronic Commerce Research	<u>Journal of the European Economic Association</u>	<u>Socio-Economic Planning Sciences</u>
<u>Economic Geography</u>	<u>Insurance: Mathematics and Economics</u>	Journal of Empirical Finance	<u>Journal of the Royal Statistical Society, Series A: Statistics in Society</u>	<u>Socio-Economic Review</u>
<u>Economic History Review</u>	<u>International Business Review</u>	<u>Journal of Environmental Economics and Management</u>	<u>Journal of Urban Economics</u>	<u>Spatial Economic Analysis</u>
<u>Economic Journal</u>	<u>International Journal of Business Communication</u>	Journal of Finance	<u>Journal of World Business</u>	Strategic Entrepreneurship Journal
<u>Economic Policy</u>	International Journal of Electronic Commerce	<u>Journal of Financial and Quantitative Analysis</u>	<u>Judgment and Decision Making</u>	Structural Equation Modeling
<u>Economic Systems Research</u>	<u>International Journal of Energy Economics and Policy</u>	<u>Journal of Financial Economics</u>	<u>Land Economics</u>	<u>Technological and Economic Development of Economy</u>
<u>Economica</u>	<u>International Journal of Production Economics</u>	Journal of Financial Intermediation	<u>Local Economy</u>	<u>Theoretical Economics</u>
Economics of Education Review	<u>International Relations of the Asia- Pacific</u>	Journal of Financial Markets	<u>Long Range Planning</u>	<u>Wine Economics and Policy</u>
<u>Economics of Innovation and New Technology</u>	<u>International Review of Environmental and Resource Economics</u>	Journal of Financial Services Research	Management Accounting Research	Work, Employment and Society
<u>Economics of Transportation</u>	<u>Internet Research</u>	Journal of Financial Stability	<u>Marine Policy</u>	<u>World Bank Economic Review</u>
<u>Economy and Society</u>	Journal of Accounting and Economics	Journal of Human Capital	<u>Maritime Economics and Logistics</u>	<u>World Bank Research Observer</u>
<u>Electronic Commerce Research</u>	Journal of Accounting Research	<u>Journal of Human Resources</u>	Marketing Letters	<u>World Development</u>